PRINCIPLES OF SYSTEMATIC FORMATIONS OF TROPICAL PLANTS

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(English Translation by M. K. Hendrix)

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Plant formations or types of vegetation are realities of Nature which in Europe and in temperate zones in general have never imposed the study of systems of classification and nomenclature. Quite naturally, in all the languages one named the forest, the meadow, the moor, the steppe, or more local forms like the maquis, the scrubland, without there being matter for discussions on the use of these names. or on a systematic of these types of vegetation. Moreover, to name the different kinds of forests, without any dispute, spontaneously we speak of forests of oaks, pines, spruces, beeches, etc..., because it is obvious to anyone that they are well defined by the name of the constituent dominant species.

In tropical regions all naturalists, geographers, botanists, travelers in the presence of plant formations different from those they used to see in Europe have naturally made connections with temperate forms, this is how they have believed to be able to speak of steppes, maquis, prairies, or that they adopted native terms such as savannah, or even created new terminology such as tropophilic forest, ombrophilous forest, monsoon forest, sclerophyllous forest, parkland forest, etc. Others have sometimes contented themselves with vague but commonly used names such as bush, brousse, scrub, coppice, etc. As the knowledge of the tropical countries extended and consequently a descriptive literature, the nomenclature of the vegetable landscapes proliferated, each author having his own terminology, so much so that if he wished to make himself understood he had to add a glossary of words employed where he specified the meaning he attributed to each of them. In all the languages the confusion was great and still remains so. In fact, we see in tropical countries types of vegetation which are not quite the same as those in temperate countries; the humid tropical forest cannot be compared to any of our forests in France, the wooded savannah is exclusively tropical, as are the gallery forests, etc. How can we also distinguish between them and the dense humid forests of the Congo, the Amazon, of Malaysia, physiognomically similar, but very heterogeneous forests where generally no single species characterizes the formation on its own at first sight?

Moreover, the clear division of the temperate countries of the old civilization into crops, meadows and forests, where the smallest parcel of soil is demarcated, surveyed, with very apparent limits, this division generally no longer exists in tropical countries. Between the primary forest and the temporary crops installed in the forest there are multiple intermediate facies, old secondary forest, young or recent secondary bush, forest or mixed savannah, which are considered by the inhabitants as forest fallows, both man and nature have contributed to diversifying plant landscapes.

The need to standardize terminologies, to also create new ones for certain cases is recognized by all the naturalists who, moreover, do not fail to propose them and are most often ready in this way to always increase the confusion. However, each time they meet in Congresses they never fail to insist on this need to establish definitions and a nomenclature. This is even more obvious when it comes to mapping tropical vegetation. As in the literature, recourse is had to annexed explanatory notes, giving the meaning that should be given to the names which refer to the different kinds of types of vegetation mapped. Without these notes the map remains incomprehensible. But from one map to another, the legends change. To compare these maps, you have to interpret: the steppe here is the savannah there! What is a scrub, a bush?

The International Botanical Congresses, in Amsterdam in 1935, in Stockholm in 1950, in Paris in 1954, insisted on the need to codify the vocabulary of plant formations. Recommendations along

these lines continue to be presented at all international meetings of botanists and foresters. I will mention for having attended, the Inter-African Forestry Conference of Pointe-Noire in 1958, the Inter-African Conference of Ndola in 1959 on open forests, the UNESCO Colloquium organized in Adiopodoumé in 1959 on soils and vegetation, recently again the UNESCO Colloquium of Caracas in 1964 on the forest/savannah edges. The need for codification on an international scale appears to everyone, hence the appeals to the major international institutions which alone can bring about the essential meetings between specialists.

One of them — the only one so far — has taken an initiative in response to these wishes. The African Scientific Council (CSA) convened in Yangambi (Belgian Congo) in 1956 a meeting of plant geographers specializing in Africa, which had the particular objective of establishing a terminology common to all African plant geographers. It included qualified representatives of the governments adhering to the Commission for Technical Cooperation in Africa South of the Sahara (CCTA), an offshoot of the CSA: Belgium, Federation Rhodesia-Nyasaland, France, Portugal, United Kingdom, Union of South Africa . Experts also represented Italy, FAO and UNESCO. The objective was achieved. After long discussions, agreement was reached on a nomenclature to be recommended to all phytogeographers in Africa. It was established in two languages, English and French. The main types of vegetation in Africa were roughly defined, named and classified. Examples of published descriptions with their references were cited for each type and brief sketches of the profiles of the different types were attached.[1]

This so-called Yangambi nomenclature was widely disseminated by the CSA (publication no. 22); in France by MM. J. L. Trochain[2], and by myself[3]; in West Africa by M. Ph. D, Boughey.[4] It was widely adopted in the Vegetation Map of Africa South of the Sahara, published in 1959 by AEFAT[5] with financial assistance from UNESCO.

The experience of this terminology since 1957 allows us to say today that it met the needs of African phytogeographers. Not only is it valid for Africa but with some modifications and additions it would be applicable to all tropical countries of the world. It is used for the cartography of the vegetation of India undertaken by the French Institute of Pondicherry, under the direction of Mr. Gaussen. Legris used it without the slightest difficulty in his thesis on the ecology of Indian vegetation.[6] Likewise Viart in his thesis on India.[7] I also established for Brazil and Mexico the correspondence between the terminology of Yangambi and the local vocabularies.[8] I am now convinced that on the basis of the Yangambi document it would be possible to establish a universal terminology, in several languages. But the consent of the most qualified phytogeographers of the main tropical countries would be essential beforehand. The confrontation of opinions would no doubt be fierce, because habits have been adopted by everyone in this matter of nomenclature, but common sense and the interest of an agreement should prevail. Phytogeography like any science needs a universal vocabulary, and phytogeographers must remember the Tower of Babel.

However, the Yangambi project did not put an end to the discussion. It was a very general framework, including the definition of major plant formations. But subdivisions remained possible, on regional scales, because Africa is so large that certain types of vegetation could have escaped the phytogeographers present at Yangambi. And indeed gaps remain to be filled, for example:

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1. Thanks to the forester-botanist from Congo Belge R. Devred.
2. Accord interafricain sur la définition des types de végétation de l'Afrique tropicale. Bull. Inst. Et. Centrafr. 13-14 : 55-93 (1957).
3. Accord à Yangambi sur la nomenclature des types afracains de végétation. Bois, For. Trop. 51 : 23-27 (1957).
4. The Physionomic Delimitation of West African Vegetation Types. Journ. West. Afr. Sc. Ass. 3, 2: 148-165 (1957).
5. A.E.F.A.T. Association pour l'étude taxonomique de la Flore d'Afrique tropicale.
6. Legras P., Végétation de l'lnde, Écologie et Flore (1963).
7. Viart M., Contribution à l'étude de l'action de l'homme sur la végétation dans le sud de l'lnde (1963).
8. Aubréville A., Étude écologique des principales tormations végètales du Brésil (1961).

1. between the dense tropical humid or dry forest and the thicket there is no intermediary provided. However, closed forest formations that are low but higher than the thicket require a special name. I used that of low forest for tropical forests with a single storey of a height of about fifteen meters.
2. For dense ligneous formations, only thicket is provided; the equivalent of moorland is missing to designate closed formations composed of under-shrubs and herbaceous plants.

Finally, the nomenclature of plant formations should be supplemented by an agreement on the nomenclature of biological forms; that everyone agree on the definitions: for example those of shrub, shrub, sub-shrub, vining shrub; several height categories in trees; of undergrowth, etc..., and that everyone sticks to it in practice.

However, much has been written on these definitions of tropical plant formations, as the bibliography cited in the appendix will show, but no doubt either too much or not yet enough because at each meeting of phytogeographers they are still discussed, and certain words are not yet always used wisely, for example: open forest, woodland, parkland. In 1956, I myself was the author of a report entitled “Essay on classification and nomenclature of African forest formations with extension of the proposed system to all forest formations in the tropical world”. I had been entrusted with this study by a request from the Inter-African Forestry Conference of Abidjan in 1952. It served as a basis for discussion at the Yangambi Conference of 1957. But it remained unpublished. My purpose is to repeat it here, taking into account everything published on this subject since 1957 that has come to my attention. This will be my contribution to the future Intercontinental Conference that we hope for, and in a more immediate way to the desirable dissemination and fixing of a terminology that is still too little known. The diagrams due to the talent of N. 11, assistant to the Phanerogamy Laboratory of the Museum, will make the accomplishment of this plan easier.

PRELIMINARY GENERAL CONSIDERATIONS PRINCIPLES AND METHODS

The definitions of plant formations, their classification and their nomenclature can be envisaged according to four orders of considerations: physiognomic, ecological, floristic, evolutionary (syngenetic). Everyone generally agrees that the basis of a classification is primarily physiognomic. Describing and classifying the types of vegetation as we see them is naturally a priority. The formations appear immediately different to us, it is a question of analyzing our impressions, and of bringing out the elements of the vegetal landscape which characterize and differentiate. A classification based on physiognomy can be used by all observers of all disciplines. It must enable them to recognize any type of vegetation in nature and to give it its name. It would not be the same for a classification based on the other principles.

Only very specialized botanists could use a floristic classification. Syngenetic or ecological classifications can only have a less universal character, but they allow by their very essence a better understanding of the types of vegetation.

But is it possible to resort to physiognomic elements alone? To establish the general framework of a classification, certainly yes, but when it is necessary to subdivide this is doubtful, so I am convinced that at a certain stage of the investigation it is preferable, if not necessary, to resort to floristics and ecology.

The Yangambi system has a physiognomic basis, but it concerns only major African vegetation types. The major categories also have an ecological rather than a physiognomic nomenclature: "Elimalic forest formations, low and middle allilud forests, dense humid forest, dense dry forest, summer..." It is obvious that certain formations are immediately characterized by their topographical and therefore ecological situation; high mountain forests as opposed to low and middle country forests, gallery forests, riparian forests, periodically flooded forests, etc. To disregard their ecological position would be absurd. In reality, one cannot avoid linking physiognomy to ecology, since the first is causally dependent on the second. It is because certain climatic and soil conditions prevail in a region that it is covered with dense humid forest, savannah or steppe. Training is the effect of the environment, this is well accepted today. It must therefore be possible to establish a physiognomic classification and an ecological classification in parallel. If this has not yet been done on a universal level, it is because many environmental data are still lacking in tropical countries. However, these investigations are well advanced. We know the ecological conditions which dictate the presence of a dense tropical humid forest in all the continents, or of a wooded savannah, or of steppes, etc. When these investigations are complete from the double point of view of territory and from the subtlety of the climatological and edaphic analysis, the table putting in parallel the physiognomic and ecological definitions of the tropical plant formations could be established.

Evolutionary investigations are also essential to understand the presence of certain types. The physiognomic classification of Yangambi refers to the “Secondary forest” with these evolutionary facies: “recruited, reworked forest” or agrological “forest fallow”. It was inevitable. Human occupation in tropical countries has been manifested since time immemorial by considerable clearing and burning of areas, which have transformed the forms of the vegetation and have often caused the primitive formations to disappear completely or almost completely. So that we see today certain types of vegetation which apparently are stable, but which in reality are evolutionary types of biological regression or progression. The environment-vegetation balances that we observe today are only pseudo-balances, "instantaneous" unstable balances. Phyto-geographers have demonstrated the notion of series, that is to say the succession of several evolutionary types descending from the same primitive climatic type. The design has a certain scientific interest but, at least as regards tropical countries where these dynamic aspects of vegetation are not well known, it still has a conjectural and controversial character which must inspire caution. For example, I defended the thesis, using floristic, biological and experimental arguments, that most African wooded savannahs - and others - are the result of the secular action of clearing and bush fires from the degradation of former dense dry forests that have now almost completely disappeared. This conception is still not always accepted by certain phytogeographers who continue to think that these wooded savannahs are dimactic formations only slightly modified by fires and clearings. The notions of climax, with these auxiliaries: pseudo-climax, para-climax, post-climax, pro-climax, plesio-climax, etc... correspond to real stages in the evolution of vegetation, they are also convenient expressions of thought, but their application in tropical countries still has a hypothetical character which should not be underestimated.

After these preliminaries, let us retain the idea that a classification will therefore be essentially physiognomic, but let us also recognize that it will gain from being completed and clarified by ecological and syngenetic considerations.

It will necessarily also become floristic when the physiognomic elements come to be insufficient. The same formation can in fact consist of multiple floristic communities that it is sometimes agreed to call floristic “associations”. It is obvious. How are we going to distinguish between them and name multiple types of wooded savannas, open forests, evergreen or semi-deciduous moist forests without appealing to the floristic elements? Physically they look alike. Perhaps by pushing the physiognomic investigation to the extreme we could bring out certain

elements of apparent differentiation, difficult to appreciate and often probably fallacious as to their comparative value, whereas the study of floristic compositions, very simple in certain case, allows precise definitions. It is impossible at a certain degree of analysis to escape floristic considerations so much for defining, classifying and naming. I will expand on this subject, by way of example, about dense humid forests.

In Yangambi, other practical considerations were taken into account for the nomenclature. African nomenclature excluded terms used in certain parts of the world to designate very local types of vegetation that there did not seem to be any interest in generalize, or names used in very different senses in different countries and then becoming too confused to be remembered. Were rejected as follows: “scrub” very widely used in descriptions of thickets, but also of dense humid forest degraded by crops, or even in Australia to designate dense humid forest (“rain forest”) as opposed to “forest, » this name being reserved for the Eucalyptus forest alone, « Eucalypt forest »; also "brousse" or "bush" which is practically applied to all vegetation outside cities; or more geographical terms like “llanos”, “pampas”; it seemed preferable to the meeting to retain "maquis" in its original sense in the Mediterranean region, although in fact it is now commonly applied to vegetation types in California, Cape Town, New Caledonia . The maquis was considered to be a Mediterranean form of the universal type: "fourré" in French, #thicket" in English, defined physiognomically in a very general sense.

Finally, conversely, in Yangambi, account was taken as much as possible, in the choice of terms, of already established usages when these were not ambiguous, rather than coining new words. Very absolute minds could have rejected the terms 'savannah' and 'steppe', for example, because they were sometimes applied to formations that were not clearly defined, or wanted to confuse them with 'grassland'. In tropical regions, these words savannas and steppes are now in solidly established common usage. They certainly have a meaning as clear, although very broad, as the word "forest" which also applies to extremely varied formations of all climatic zones. I think these decisions were wise and would apply to any meeting on a higher international scale. Other climatological expressions should not be accepted in a universal classification, such as "monsoon forest". These forests are indeed adapted to a climatic rhythm including a very rainy season (due to monsoon rains reinforcing the summer rains) followed by a very dry season. A correlative biological rhythm is manifested, for example, by the partial or total caducity of the foliage which makes it possible to classify these forests among deciduous or semi-deciduous forests. The syngenetic mention of the monsoon effect is therefore not essential in the physiognomy nomenclature.

In defining training, three remarks should be taken into account. One is simple routine observation. We pass in fact from a well determined formation to another equally well typified, often by transitional faeces. Sometimes the passages are abrupt and the dividing territorial limits are quite easy to draw with precision. This is the case of forest/savannah edges and areas where changes in the environment are sudden, as often happens in the mountains. The definition of a formation must therefore apply to the plant groups which on average seem to characterize a well-determined type, and not to groupings of transitions.

Very often, especially in semi-arid countries, we observe not a homogeneous plant formation over large areas, but a mosaic of formations. These mosaics have been given regional names which should not be understood as designating actual plant formations. For example, the Brazilian "Catinga" is a mosaic of dense low deciduous dry forests, thickets and thorny steppes, thus of three mixed formations, confused in appearance. Similarly, the “Indochinese clear forest” is a mosaic of clear forest proper with Dipterocarpaceae, wooded savannah, and dense dry forest. Gallery forests in semi-arid countries of wooded savannahs are not strictly speaking plant formations but "plant landscapes", which can include together strips of riparian forest, periodically flooded forest, and even dense dry land forest, so again a mixture of at least three different formations.

DESCRIPTIVE ELEMENTS OF A PHYSIONOMIC CLASSIFICATION

I. — FOREST FORMATIONS

STRUCTURE

The physiognomy of a plant formation is first and foremost its structure. This one is staged; the floors, sometimes badly separable, have an average height. These data are essential to describe a forest.

There are more or less three floors in the dense humid forest. Often upper storey trees have contiguous crowns, so that in vertical projection (plane view) the appearance of the forest canopy is polygonal; in profile the contiguous peaks of the upper level form a continuous canopy. Very frequently this cover, with an average height of 25-30 m, is dominated from place to place by crowns, generally very developed, of very large trees which emerge above the forest (appearance of cauliflowers seen from 'plane). These “emergents” are a remarkable characteristic of certain primitive forests, especially since they belong to only a few species. In other types of forest, on the contrary, the upper level of the crowns is very indented, very “open”, to the benefit of the underlying levels. The latter are more or less clear and continuous. The crowns of small trees and shrubs are of two types: either narrow crowns with few leaves, generally carried by very straight trunks, or on the contrary very dense crowns. The luminosity of the undergrowth is related to the existence of these types of crowns.

The population density depends on the continuity of the cover of the different levels. This density is expressed in different ways, either by estimating the vertical projection of the crowns or "degree of cover", or by the number of stems per unit area (hectare), these classified by categories of diameter, or by calculating the "basal area", i.e., after measuring each diameter or circumference taken at breast height, the total area calculated per hectare of all the stems.

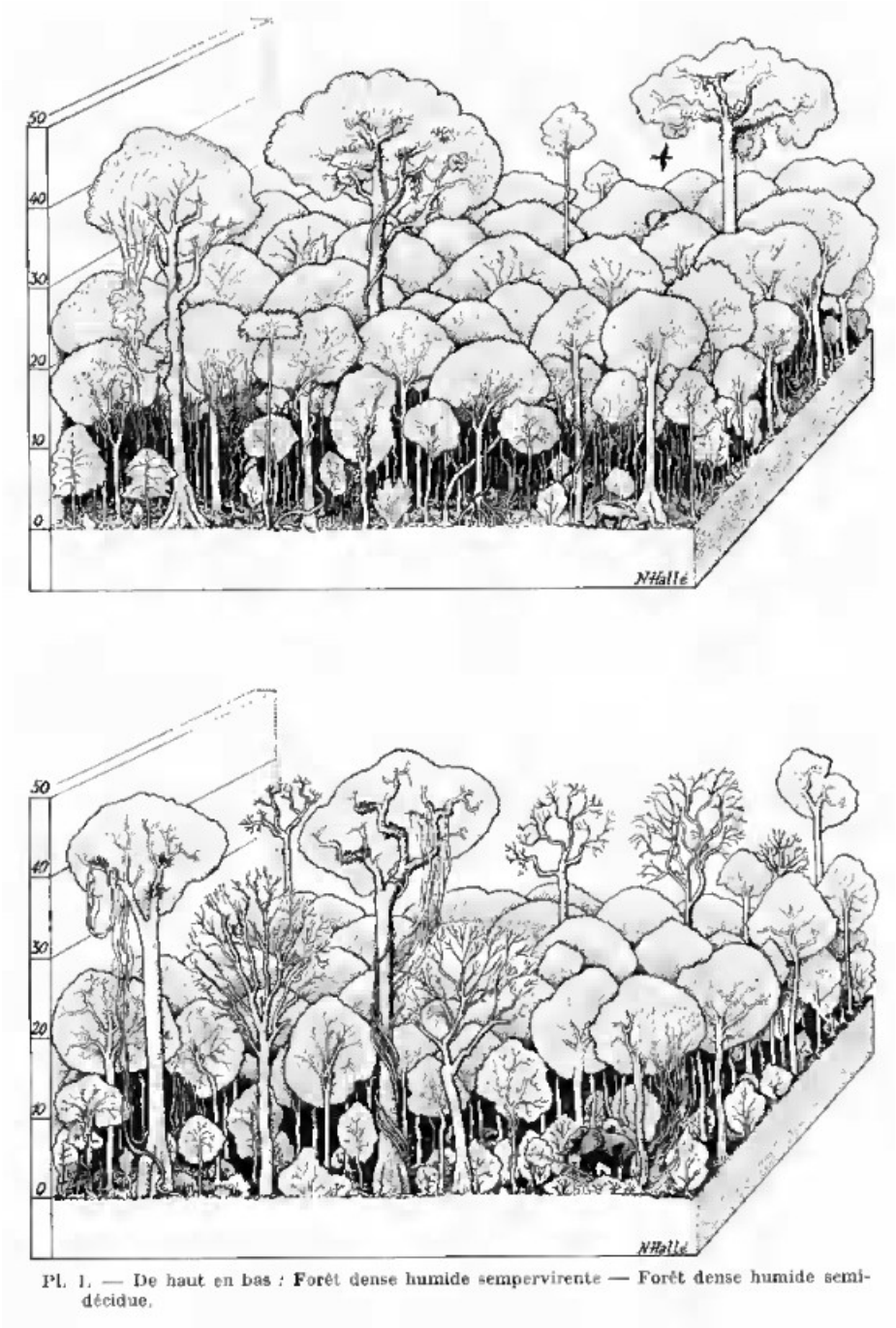
The description of the structure of a specific forest can therefore be precise, but we do not believe that one can easily multiply subtypes on this sole consideration, because of the too many possible transitions involving great difficulties of appreciation. , and the discontinuity as well as the frequent overlapping of the floors.

The height of the canopy makes it possible to separate two important categories of closed forest formations; the “forest” proper and the “thicket”. The thicket is a low, dense, essentially shrubby formation, the cover of which has a maximum average height of 7 m 1 . It can often be dominated from place to place by a few small trees. The “coppices” are therefore thickets, but having a precise forest meaning of forest regrowth by rejection of stumps after clear-cut exploitation of the forest.

The terminology of Yangambi lacks a word to designate the dense low forests with a single storey, which are frequent in tropical countries, often under particular edaphic conditions. We therefore propose the term "low dense forest" for closed dense forests whose canopy is at an average height not exceeding 15 m, a few isolated trees being able to emerge from the continuous canopy.

Similarly, it seems useful to me to adopt the term "wood-thicket" used by LEGMS in his descriptions of the vegetation of India, which designates a thicket from which quite a number of small trees emerge, these trees not forming however not continuous cover. We would then have the

series “thicket-thicket-low forest” which would facilitate the description of all these types of transition between a true shrubby thicket and a low forest.



Pl. I. — De haut en bas : Forêt dense humide sempervirente — Forêt dense humide semi-décidue.

A crucial distinction applicable to all types of vegetation lies in the “closed” or, on the contrary, “open” character of the cover. Under a closed canopy, the amount of light that reaches the undergrowth or the ground itself is low, it controls the relative development of the shrubs in the undergrowth and the herbaceous cover. When the cover is open, the lower strata conversely take on a great development. This consideration is essential in countries with a semi-arid or arid climate, where the undergrowth, vines, grasses and shrubs under very open forest cover become dense and then susceptible to fire in the dry season, which causes considerable disturbance. in the original formation.

There are also forests where the upper layer of trees (high forest) is very open; the trees are thus widely spaced above a dense and closed undergrowth. In the Sangha basin there is another type of

dense humid forest with a very open high forest above a dense undergrowth of large herbaceous plants (Marantaceae). In the vegetation map of this country Rollet has improperly named "clear forest" term which we will see later must keep the very particular meaning that has been recognized in Yangambi, under pain of confusion.

Physiognomy is not just about structure. Biological forms other than trees and shrubs are of great importance in tropical forests: epiphytes and lianas, then also herbaceous plants, mosses and lichens. Their abundance is a characteristic of forests, linked to the prevailing ecological conditions, atmospheric humidity for epiphytes, soil humidity for lianas. The separation of large woody lianas and small threadlike lianas from the undergrowth deserves consideration. A very creepy forest whose creepers grow in dense ramifications in the treetops has very dark undergrowth. We must add the more specific cases of terrestrial epiphytes, trees of epiphytic origin, strangler Ficus.

Finally, the herbaceous carpet in the forests is also an important element. Its height, its degree of covering, its continuity, can be appreciated, 11 is related to the nature of the ground and especially with the luminosity of the undergrowth.

The presence of plants with typical shapes cannot be ignored, especially if they are abundant, since it gives the appearance of the whole a particular aspect. This will be the case with the palm trees, sometimes absent in the tropical forests, sometimes on the contrary very remarkable either in the storey of the trees, or in the undergrowth; creeper palms, tree ferns, large monocotyledons (Dracaena , Pandanus), large herbaceous plants (Marantaceae, Zingibèracées, Bambusées, Rapatèaceae, etc...).

Certain dry tropical formations offer specific cases of trunks remarkable for their shape, such as the bottled stems of certain bombacacécs and caesalpiniées, the pot-bellied stems of the Pachypoditim, of certain Vïfis, Adenium, the succulent forms (tree euphorbias). More generally, the dry formations are characterized by the presence of multiple species of thorny plants, succulent plants (cacti, euphorbias), and extraordinary trees or shrubs such as the Malagasy didiéracées. The not uncommon presence of cauliflorous trees in the humid forests also deserves to be pointed out as a truly tropical element.

The habitual form of the trees of a formation is a character which often deserves to be retained to define it. For example, the perfect straightness and great height of the free part of the bole of high forest trees in dense humid forests, as opposed, for example, to trees in other forests where the thickness of the crown is greater than the free part of the trunk. Among large trees, the presence of buttresses is perhaps the most salient characteristic of tropical rainforests and sometimes even of dense dry forests, peculiar to many species. This is one of the most apparent differential characters which distinguishes them from temperate forests.

The shape of the crowns of some species of large trees, when abundant, also give a special character to the forest, for example the stepped parasol crowns of Terminalia, the narrow spindle crowns, the conical crowns, the flamboyant pyramidal crowns , etc...

Stilt roots, roots with pneumatophores, roots with geniculate yawning appendages, arched roots, are the prerogative of mangroves, but trees with bundles of aerial roots are also found in swampy forests and even in dense humid forests. of dry land.

special mention should be made of coniferous species. These are not common in tropical forests. There are none in Africa except in the high mountains (Podocarpus, Juniperus, Whijdringlonia). But in Malaysia, Australia, New Caledonia, conifers are sometimes found mixed in the deciduous forest. The dense rainforest formations mixed with Arauearia high forests are among the most remarkable

in Australia and southern Brazil. The forests of pines and oaks are also very important subtropical formations in Mexico at altitude.

Mountain forests have very specific structures, profiles and therefore physiognomies.

Profile diagrams, — The structure and physiognomy of a formation can therefore be the subject of precise detailed descriptions and measurements. Many phytogeographs today use the technique of profile diagrams to represent the profile and density of a formation. The diagrams drawn by certain authors already give an idea of the profiles of the formations and make the descriptions livelier, but their value depends very much on the observer who interprets his impressions more or less subjectively. The profile diagrams reconstitute by drawing as exactly as possible the profile of a forest formation. These are precise documents which show the profiles - on a very small scale - that can rarely be seen, except when, thanks to clearing in the forest for example, or the opening of a road, a clean cut has been made. made and that we have enough distance to see the silhouette of the cut made in the forest. The drawing gives a faithful and more readable representation.

The very simple method of application comes down to the delimitation in the formation of a narrow and long corridor (100 m X 5 m for example), its cutting into squares on the ground, then the measurement of the height (barrel librecime) and the diameter of all the trees and shrubs, noting their position on a plan, square by square. We then have all the elements to reproduce on a squared paper the profile of the forest as we could see it. To be complete, we also note all lianas, epiphytes, herbaceous plants at least on a small surface. The floristic composition is obviously noted. Similar profiles when drawn to the same scale make comparisons between forest types easy.

A single drawing probably represents only a particular case of the profile of the formation; it is therefore appropriate to choose the plot studied in a part of the forest which appears to be well representative of its average appearance. This process only gives an imperfect idea of the density of the cover, since the tops of neighboring trees whose vertical projection overlaps the plot do not appear on the drawing. Despite this flaw in the method, it is one of the most representative there is, and a profile diagram will always accompany with great interest for the reader a description of a forest type.

Lamphecht tried to improve its representative value, by superimposing the drawings of two contiguous parcels, one of the two drawings being traced on a sheet of transparent paper.

Some published documents with a lot of detail are remarkable. The process was applied by Hosokawa, a Japanese botanist with extreme meticulousness for the study of the distribution of epiphytes on trees, their presence at various levels of the stem and the crown being a specific character.

Many efforts are therefore currently undertaken by phytogeographers to give precision to physiognomic methods. The profile diagram process is applicable to all types of plants, including herbaceous types. But so far it has been mainly used for forest vegetation. To my knowledge, only the Belgian botanist Louis used it to represent the herbaceous carpet of the humid tropical forest of the Congo.

BIOLOGICAL SPECTRUM

A formation is a biological unit where the space occupied by vegetation (by biomass) per unit volume is made up of a set of life forms distributed on average according to defined proportions. The average percentage of the number of trees divided into several categories of diameter, shrubs, sub-shrubs, epiphytes, lianas, is a characteristic of the formation. It constitutes the true biological

spectrum of the formation, a notion different from the spectrum also called biological which determines the percentage of the number of species by biological forms.

An approach to the biological spectrum of the formation can be made during the readings and measurements carried out in the plots studied in order to reconstitute the profile.

But often we will have to be satisfied by sight estimation to recognize the abundance, for example, of very large trees, the density of the undergrowth, the abundance of lianas, epiphytes, the density of the herbaceous cover, etc.

LEAF DIMENSIONS

Another physiognomic element may intervene in certain cases, the dimensions of the leaves. LJ Webb made it one of the main elements of a classification of the “rain forests” of Australia 1 . Raunkiaer established a classification of sheets by dimensions. Adopting the limits of the latter and adding a category of intermediate notophylls between mesophylls and microphylls, which seems to him better adapted to current dimensions in the Australian "rain forest", Webb makes the relative proportion of mesophylls, notophylls and microphylls the line heads of its sub-formations.

No study of this kind having been made to my knowledge in other tropical countries, it seems impossible to retain the criterion of leaf dimensions in a universal classification, at least as the main criterion. It is certain that the dominance of one type of leaf in trees imparts a particular physiognomy to the forest. For example, some large legumes have spreading, umbrella-like crowns and very small leaflets, so the canopy is very transparent. Seen from below it gives the appearance of fine lace.

FOLIAGE DECISION

An important biological element makes it possible to divide certain formations having the same structure and, in the rainy season, the same physiognomy: the permanence or the caducity of the foliage. There are dense evergreen forests whose tops remain leafy and green in all seasons; leaf fall occurs gradually without the tops ever appearing bare. There are deciduous forests, where for a more or less long period in the dry season the crowns are completely defoliated. Between evergreen forests and deciduous forests, one can observe intermediaries where only a fraction of the crowns are defoliated. One may be tempted to specify and divide into forests where 1/4, 1/2, 3/4 of the tops are defoliated. It is difficult to assess the proportions, and moreover the middle of the forest is not absolutely uniform, the impression of the defoliation can vary from one site to another. In Africa, at Yangambi, only one division has been admitted, the semi-deciduous dense humid forest. Furthermore, the criterion of partial leaf fall in the dry season is coupled with a floristic composition that is notably different from that of the evergreen dense humid forest.

Defoliation only occurs in the high forest, in the tallest trees, the lower floors and the undergrowth remain green. There again, transitional types exist up to the totally deciduous forest where trees and undergrowth are totally leafless, such as the Brazilian catinga, the dry forests on the edge of the Caribbean Gulf in Venezuela, or even certain forests in western Madagascar. In the sun, in the middle of the dry season, they appear absolutely white.

Other types of dense humid forest are more tropophile than frankly evergreen or deciduous. Leaf fall occurs at about the same time in the dry season, but the new foliage immediately replaces the old so that the crowns remain leafy, the difference being only in the colors of the crowns. The young foliage is soft green, beige, grey-green, so the tops are colored, while the old foliage was a uniform dull green.

Sometimes even certain branches bear their old foliage, while others on the same top are already covered with new leaves.

It is therefore difficult with a view to a classification to base too many physiognomic divisions on the character of the defoliation and it seems prudent to limit oneself to a few categories by broadly interpreting, more and less, the term "semi-deciduous" by example.

In general, forests and thickets that must endure a dry season of several months are deciduous or semi-deciduous. There are also, but more rarely, evergreen forests and thickets although subject to a long dry season. This is particularly the case of sclerophyllous forests whose tough foliage is persistent. The *Eucalyptus* forests in Australia fall into this category.

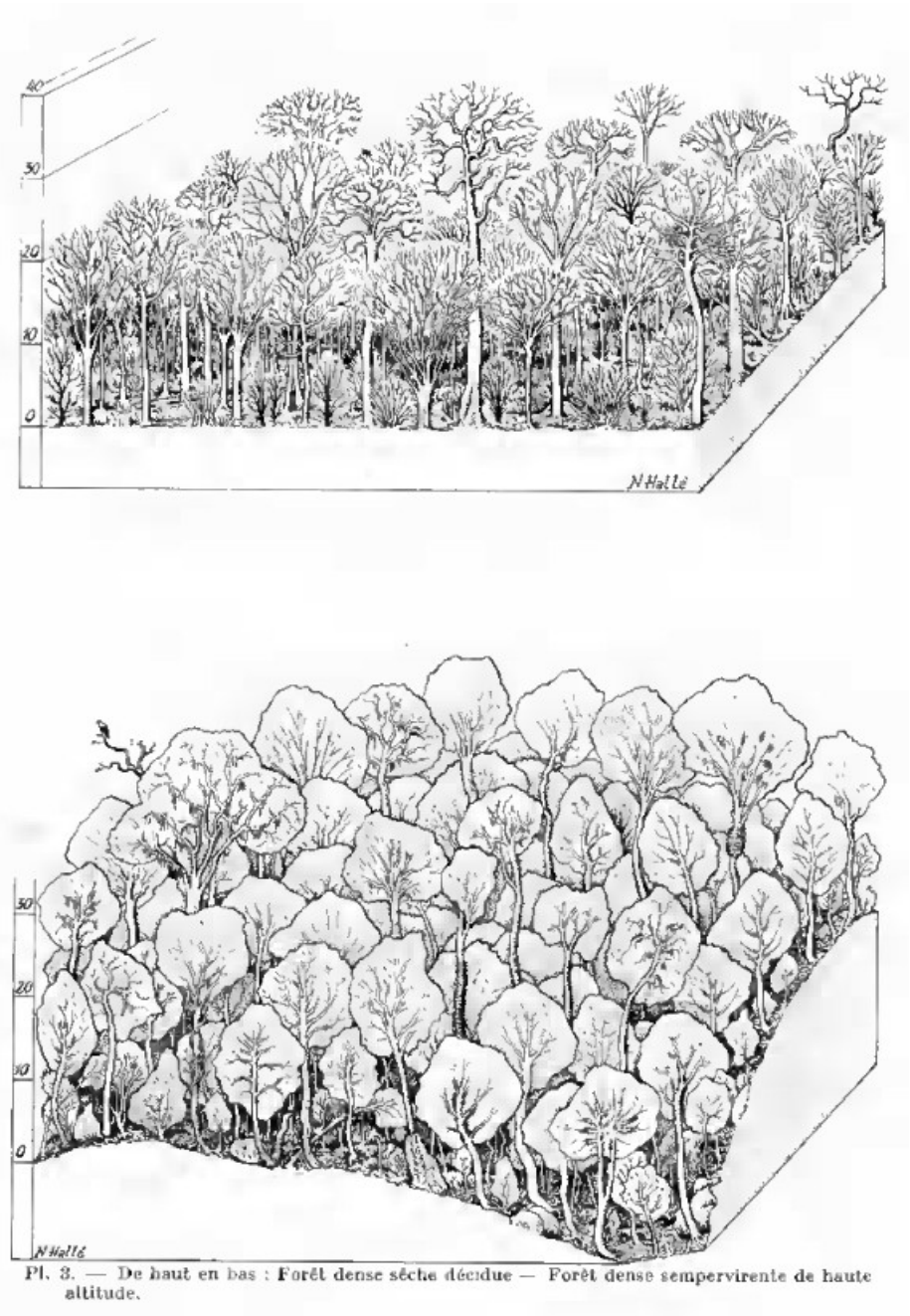
NOMENCLATURE

For the convenience of classification and nomenclature, we have already said that it would be absurd not to highlight whenever possible the mention of the habitat, when this is in a patent way the determining factor. of training. We therefore distinguish: a large category of high mountain forests, as opposed to that of low and middle country forests (plains and hills); all edaphic forests; the highly specialized mangrove formation of salt or brackish water on muddy bottoms; swamp forests, riparian forest fringes, periodically flooded forests, peat forests.

The forests and thickets on white sands are edaphico-climatic formations which can be considered rather as sub-formations of the dense humid forests within which they are found. They are very sufficiently characterized by the soil, the physiognomy and the floristic composition. I don't know of any examples in Africa. Here should be ranged the thickets on the white sands of the upper Rio Negro (pseudo-catingas) in Brazil, and the "Heath forests" of Borneo (in *Casuarina* and *Dacrydium*).

Homogeneous forests. — The nomenclature of all these formations with determining edaphism does not present any difficulty because they are generally quite homogeneous with a small number of visibly dominant species. It is therefore sufficient to add the name of one of these principal characteristic species to that of the formation. Riparian forest at *Mora excelsa* (Guianas). Low forest on white sand in *Humiria* (humirizal of Brazilian Guyana). Riparian forest with *Capaîfera Demcusii* (Congo), Swamp forest with *Pierocarpus, Virola* (Guianas), Mangrove with *Rhizophora, Avicennia, Bruguiera*, etc.

The case is exceptional, but there are also dense tropical forests where clearly a species of large tree is dominant and gives a particular physiognomy to the forest. This is the case of the *Gilberliodendron Dewevrei* forest of the Congolese basin which, by its considerable extent and its very special aspect, deserves the rank of a sub-formation. Its name speaks for itself. This is also the case of coniferous and fagaceae forests in the mountains of the tropical zone.



Pl. 3. — De haut en bas : Forêt dense sèche décidue — Forêt dense sempervirente de haute altitude.

Heterogeneous forests. — The general case remains embarrassing, that of heterogeneous forests, those which are not linked to distinctly special environments. To distinguish and name them it is impossible to do without the competition of floristics. Some botanists have thought of using the methods of analysis, the hierarchy and the nomenclature of the so-called Montpellier-Zürich phytosociological school. Personally, I do not agree on the principles of the method which, at the base seeks the characteristic species of a community (association) — in the comparisons of floristic surveys carried out on very small surfaces, — among the species so-called differentials revealed by these comparisons would exist only in this community, then designated according to the name of one of the exclusive species. These characteristic species may be constant and abundant but in principle could be rare. Then the “associations” are grouped into “alliances” when they have species in common that exist only in this group of associations. This floristic edifice is accompanied by a scholarly nomenclature reminiscent of the Latin nomenclature of plant species, the use of which seems easy only to specialists.

We believe that the characteristic species of a forest are those which have shown the most vitality in the interspecific competition which is fierce in dense tropical forests, and which results in their particular abundance in the stand. These are the species that essentially constitute the community, those that best represent it biologically and physiognomically. They must therefore serve to name it; it doesn't matter if they also exist in other different communities.

When a species is more than abundant, that is to say dominant[9], it imposes itself immediately to name the community. When the formation is heterogeneous, which is the general case, inventories are necessary, preferably covering large areas. The study of these inventories undertaken by sampling on scattered plots makes it possible to identify these characteristic abundant species. All those that I have been able to study, which sometimes covered tens or hundreds of thousands of hectares, in Côte d'Ivoire, Cameroon, Gabon, Mayumbè, French Guiana, Amazonia, the Central African Republic, show that out of the 100 to 300 species of trees inventoried in the formation, there are always about ten species which together form more or less half of the total number of trees. These are the true characteristics of training. The many other species are scattered they are filler species.

These few abundant species are not evenly distributed. One that is gregarious here, may be absent there. They form an invariant set whose combinations qualitatively and quantitatively vary in the space occupied by the formation, then also in time. They represent the static but multifaceted climax of this formation. It is therefore among them that it is appropriate in principle, and preferably, to choose those which will designate the training.

A nomenclature that must remain simple to use obviously cannot use several species names. A given forest can be designated by one or two of the locally most characteristic species. When it is a question of a large formation, it is necessary to synthesize and highlight not the species, but as much as possible the genera and even the most striking families. In a classification on the scale of a continent or even universal, it will inevitably be necessary to rise to the scale of families. Thus the Indo-Malayan dense humid forest is well characterized in absolute value and in relative value compared to the Guineo-Congolese and Amazonian forests by the expression "Dense humid forest with Dipterocarpaceae" or even more precisely "Dense humid forest Indo-Malaysian to Dipterocarpaceae". In the Guineo-Congolese chorological region, the forest of the northern peripheral domain seems to me to be called "dense semi-deciduous humid forest with malvales and ulmacées"[10] as opposed to the dense humid forest of this region which seems rather characterized by the abundance of large legumes.

Descending from the great formation to a specific forest, we can call on the names of genera or species: Triplochilon forest (in ayous), Tarrielia forest (in niangon), Turreanlhus forest (in avodiré) for example in Côte d'ivoire, here, in these particular cases, without Latin species name since these three genera each have only one species in Côte d'Ivoire.

We will again make this remark that it is in our practical logic to choose the names among the species of large trees in the canopy belonging to the characteristic species. This choice, although conventional, is not arbitrary. It is the large, abundant canopy trees that are the main builders of the community; by their shade, their waste, their rooting they largely control the biology of the undergrowth and the soil.

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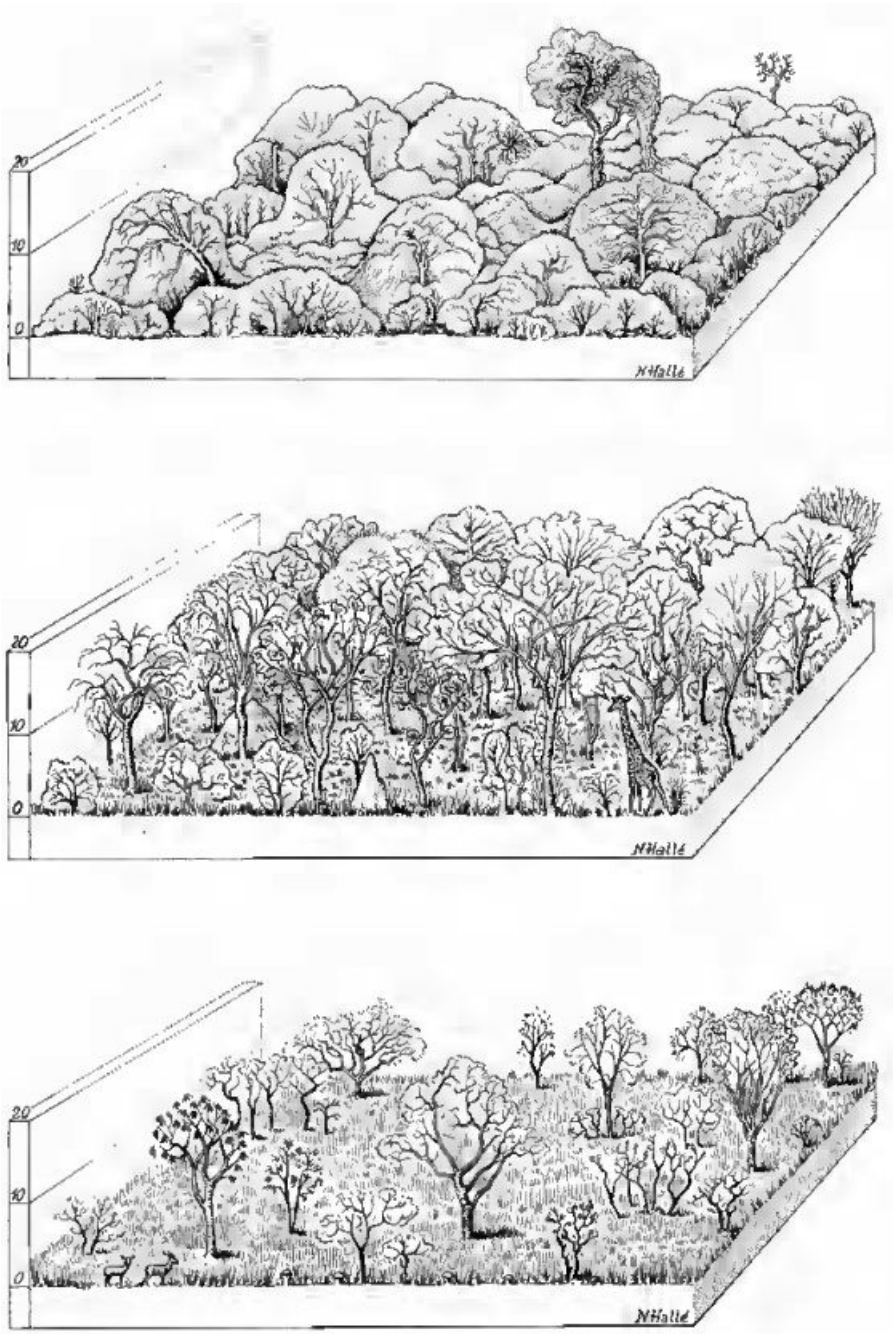
9. The word dominance unfortunately has two meanings in phytosociology, depending on whether it expresses a notion of height greater than the average height of the formation, or a higher degree of frequency.
10. Remarkable abundance of *Celtia* el Slerculiaceae.



Pl. 4. — De haut en bas : Bois fourrés, fourrés. — Forêt claire. — Savane boisée.

When in the lower floors or even in the herbaceous carpet there is a particularly abundant species, it is certainly appropriate to associate it with the tree species chosen to designate the forest.

II. — MIXED FORMATIONS

FOREST AND HERBACEOUS FORMATIONS (GRASSES), WOODED SAVANNAS & OPEN FORESTS

Under the general title are classified both: purely grassy formations (savannah and steppe), mixed formations where above the grassy stratum of savannah and steppe there is a stratum of small trees and d more or less open shrubs (the wooded savannah, the elaire forest, the wooded steppe), then transition formations. “Savannah” and “steppe” without epithet are terms often accepted in a very general generic sense and relating both to purely grassy formations and to mixed superimposed, grassy and forest formations. This is why, in a more precisely phytogeographical language, it seemed preferable to use two terms: "grassy savannah", without or with a few scattered shrubs, "wooded savannah" where the forest grouping is visibly large or even very large , and the same for the steppe.

The biggest difference between a "low" forest and a wooded savannah is that the former has a closed canopy with more or less continuous shrubby undergrowth, while in the latter the forest stand is more or less wide open, which allows a dense grassy formation, generally gramineous, to cover the ground in a continuous way. In fact, the wooded savannah is traversed almost every year during the dry season by grass fires, “bush fires”. They burn the dry grasses, but not the forest vegetation which however suffers from it, especially in its regeneration. The bush fire does not normally penetrate* into the forest, a closed formation, the edges of which it licks or grills a little. When the bush fire succeeds in particularly dry conditions in penetrating the undergrowth of the forest at the edge of the savannah, the affected plot dies and grassland quickly settles in its place.

Savannahs, wooded or not, cover considerable areas in tropical countries.

The term “clear forest” has also been introduced into the nomenclature. It was first used in Indochina to designate a wooded savannah where the small trees have tops that are almost touching. The barrels are numerous. The overall impression is that of a real low forest, but it is not a closed formation and therefore not a dense forest. The ground is indeed covered with a dense savannah of grasses. The bush fire can cover this savanna every year, but does not cause very visible damage in the forest stand. Thus between the wooded savannah and the open forest there is no difference in kind; what separates them structurally is the density and height of the forest stand and also in general, in open forest, lower density and height of the grasslands. The boundary in the field between the two types may be very indecisive, but when well characterized they are visibly different and worth nominally distinguishing; in one the forest is the physiognomically most important formation, in the other it is the savanna which is the most visible element. The trees of the open forest have a tree habit, the boles are straight; the shrubs and small trees of the wooded savannah are more or less stunted with tortuous boles. It should be added that the floristic composition of the open forest and that of the wooded savanna are often more or less different. The Sudanian open forests of West Africa are stands of *Isoberlinia* often mixed with *Uapaca Somon*; those of southern and eastern Africa are characterized above all by populations of *Brachyslegia* mixed with *Julbernadia* and *Isoberlinia*. Woodlands exist mainly in Africa and Asia. They are much less floristically rich than dense forests, humid or dry; generally one species of tree dominates and sometimes forms pure stands. There is therefore no difficulty in naming them.

From the physiognomic point of view they are monotonous. There are practically no lianas or epiphytes. The dominant species, with their particular habit, imprint on the whole an aspect which is specific to each floristic type. In the Indochinese Dipterocarpacea forests (Cambodia, Laos), the trees and shrubs generally have very straight trunks, the leaves are often large. The *Brachyslegia* of

the southern African open forests have umbrella-shaped crowns, their canopy of compound leaves with small pinnules is very light. All these formations are more or less evergreen. In leaf fall, when it occurs, it is often impossible to separate the drying action of the season from that of bush fires. The *Isoberlinia* woodlands of West and Central Africa cover themselves immediately with their new foliage after the fall of the old, in the middle of the dry season.

In tropical America I have not seen any formation of this type, but very extensive forests of pines and oaks, in Mexico are real clear forests with a grassy and herbaceous carpet. The clear forest of pines also exists in Indochina.

English-speaking phytogeographers in Yangambi have adopted as the term corresponding to open forest not that of “open forest” but “woodland”.[11] It will certainly be necessary in a future International Conference to clearly define what is to be understood by woodland. In Yangambi the term was considered as equivalent to “open forest”. But in Australia the "woodland" is a formation where the trees have a length of bole less than the thickness of the crown. Fanshawe and Beahd also designate by this term a two-storey rain forest, formed of a dense canopy 6-12 m high, dominated by a discontinuous stratum of emergent trees 18-24 in. from above.

Back to the wooded savannah. The density and average height of the forest stand are extremely variable, especially since it is generally periodically cultivated and therefore cleared. The shrubs regrow vigorously by suckers and suckers. The damage caused to them by bush fires depends very much on the mass of grassland in the savannah. As for the open forests, there are in each station a small number of dominant species in the forest stand and in the savannah. Floristics therefore makes it easy to characterize a determined or wooded or grassy savannah.

We sometimes distinguish wooded savannahs or not by the height of the herbaceous layer. There are savannahs with tall grasses, others with short grasses. Grasses are usually arranged in clumps. When they are burned, the bare ground appears between the half-charred feet of the clumps. But in living savannah the herbaceous cover is generally so thick as to seriously impede walking in unburnt savannah.

According to the relative physiognomic importance of the tree and shrub strata, several terms have been proposed in Yangambi:

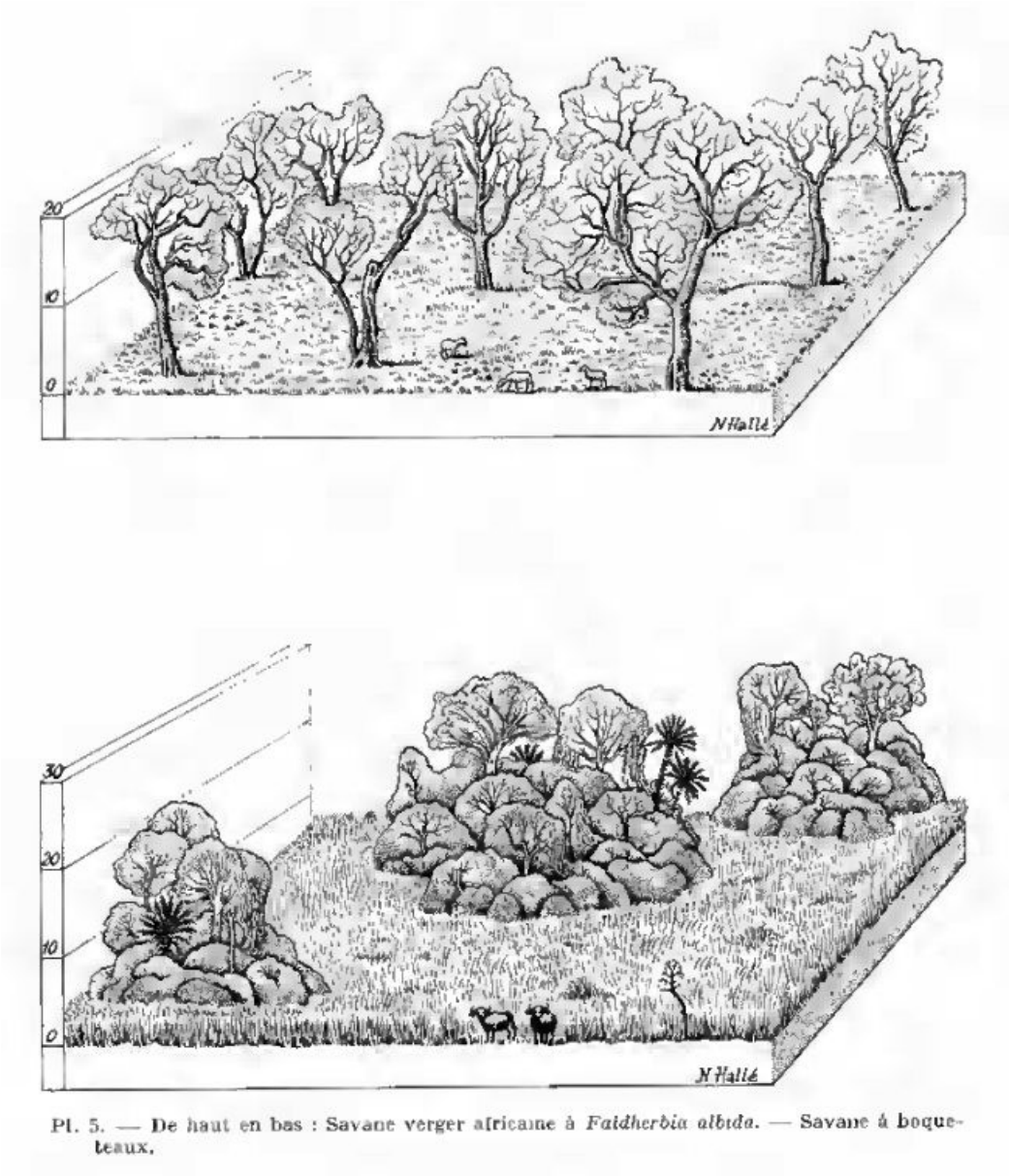
- **Shrub savannah:** No or very few small trees, shrubs and shrubs only, often stunted;
- **Wooded savannah:** Presence of small scattered trees. Forest stratum therefore excessively open.

Other physiognomic terms could be added.

- **Thorny savannah:** The shrubs are mostly thorny.

Orchard savannah: Anthropogenic type, around permanent villages in wooded savannah countries. Some tree fruit species are preserved during clearing and multiply spontaneously. In permanent or almost permanent crops, the trees remain sheltered from bush fires and can then develop their crowns normally. All the other species of the wooded savannah have been eliminated over time and there are still some sorts of orchards. Savanna-palm grove: Generally edaphic formation composed of a pure or almost pure palm grove in a grassy savannah that is often poorly drained.

11. However the report of the Conference of Ndola (N. Hhodesia) published by theAfrican Scientific Council No. 52 (1960), has the title in English: “CSA Meetingof specialists on open forests in tropical Africa”.



Pl. 5. — De haut en bas : Savane verger africaine à *Faidherbia albida*. — Savane à boqueteaux.

Savannah with shrubby (wooded) termite mounds: In open forest or savanna regions, riddled with large termite mounds, these are often covered with a small thicket of shrubs and sometimes trees, while all around the ground is covered either by grassy savannah or open forest. The forest flora of termite mounds is generally different from that of the wooded savannah that surrounds them.

Savannah with bushes: Grassy savanna where generally circular thickets are scattered. Probably facies of invasion of a savannah by flora from surrounding forests, but also sometimes on the contrary facies of regression of a forest occupied for a long time by man and savannahized.

Forest park savannahs: Term to be prohibited because often used in different senses, therefore ambiguous. Sometimes, according to the authors, it is a savannah with thickets, a mosaic of thickets and grassy savannah; sometimes just wooded savannah.

Forest savannah: Improper term, locally used in Suriname to designate thickets or low forests on sand mixed with herbaceous plants. The forest stand is dense, so it is a forest formation and not a savannah.

Few phytogeographical terms have raised as much discussion as steppe. It was sometimes used in Africa for savannah. If we refer to Russian authors, the word steppe which originally designated the grassy formations from the Black Sea to the Caspian Sea, corresponding to an arid climate, with dry summers, cold winters and spring rains, has since been extended to other grassy and shrubby formations of Central Asia, different from those of European Russia and subject to particular biological rhythms. It seems, as Trochain writes, that “this term no longer has more than the value of a geographical qualifier designating the whole of the non-forest Soviet vegetation”.

Phytogeographers were hostile to the use of the term in Africa, although recognizing that physiognomically aspects of the steppe were found in tropical Africa, because these African "steppes" have a biological rhythm distinct from that of the Russian steppes. This objection was not accepted in Yangambi since these Soviet steppes can have very different rhythms from the Black Sea to Mongolia. Steppe must therefore be understood today in the very general sense of a large physiognomic unit, just as "forest" designates biologically very diverse types of vegetation from Norway to the Ivory Coast.

A steppe is therefore primarily a grassy formation like the savannah. Yangambi's report gives a definition. The differences with the grassy savanna appear as follows:

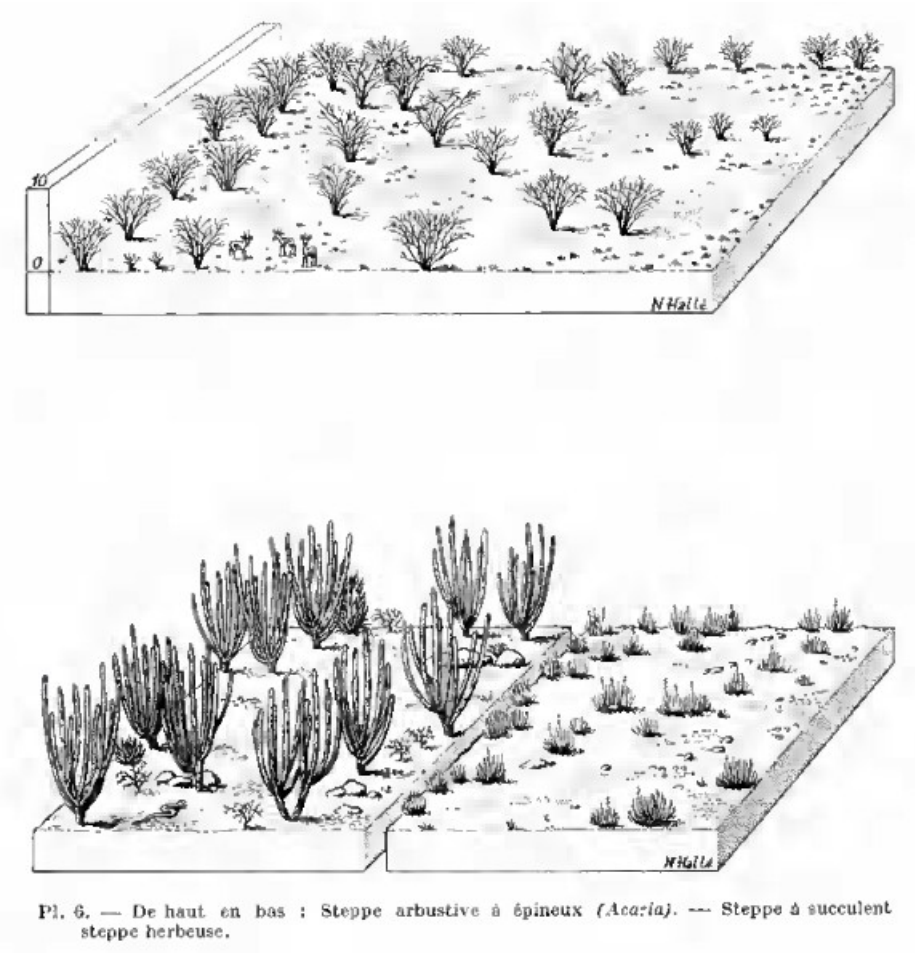
Savannah	Steppe
Continuous stratum of at least 80 cm high.	Open formation where grasses live these widely spaced only reach generally hardly 80 cm.
Flat-leaved grasses basal and cauline.	Grasses with narrow leaves, rolled up or folded, mainly basal.
Usually burnt annually.	Generally untouched by fire.

There is an obvious difference between the landscapes of the Sudanian savannas, with their high, thick grasslands where walking is sometimes difficult, and those of the Sahelian steppes, where the grass cover is sparse and more or less discontinuous. In Africa, in the Sudan-Sahel transition regions, one may often hesitate to use one or the other term to designate a landscape, and for my part I have resorted to a compromise by speaking of “savannah-steppe”. Ecologically speaking, the transition from savannah to steppe is more extreme, and the steppe ends up in the desert. However, some equatorial grassland formations have already been given the name steppe (Congo) — and rightly in my opinion[12] — in climates that have nothing to do with a pre-desert climate. This should come as no surprise, since we have already recognized that steppe is above all a physiognomic unit of vegetation. In fact, the mesological conditions of the Congolese steppes are relatively arid, despite their humid environment. savannah to steppe climatic conditions become more extreme, and the steppe ends in the desert.

But the word steppe, like that of savannah, has been extended to for mixed grassy and woody formations. The steppe has been defined for Africa trees and (or shrubs), the bushy steppe, the succulent steppe. We could usefully add the thorny steppe, which, in particular, will designate the *Acacia senegal* steppe of Mauritania. Woody vegetation can in fact take pride of place in a steppe landscape, above a thin, discontinuous herbaceous carpet. This extension of the meaning given to the term steppe, in my view, is justified by attaching all the importance it deserves to the fact of the spacing between the constituent plants. Grasses are cespitose and bare ground appears between clumps, while shrubs and bushes are generally widely spaced. Steppe vegetation becomes increasingly diffuse as environmental conditions become more arid. Seen from the air, steppe vegetation appears as a dotted line, becoming more and more pronounced as you approach the

12. Duvigneaud.

desert. How else to describe these vegetation types of cactus, agave, yucca, bromeliaceae, *Larrea divaricala*, than by “succulent steppes”, “shrub steppes”, which are so widespread in arid Mexico, dwarf undershrubs with *Cryplosepalum* de Lunda (Angola); dwarf ericoid subshrubs, succulents, bulbous plants, and in the rainy season Karroo annuals, etc... Many authors call them scrubs, but we have said that this ambiguous term should be rejected.



Pl. 6. — De haut en bas : Steppe arbustive à épineux *(Acacia)*. — Steppe à succulent steppe herbeuse.

Calling them steppes certainly extends the meaning of the word which, remembering the Russian steppe, basically meant grassy formations. Or in some shrub steppes, succulent steppes and others, the herbaceous vegetation, especially grasses, has only one secondary place, it may even be absent. To name these forms where the herbaceous layer (grass) tends to disappear, it is necessary to forge a name or give a broader extension to that of steppe. It's this last solution which was accepted in Yangambi. Trochain had proposed the “pseudosteppe” as a name.

When the bioclimatic conditions approach those of the deserts the grassy or shrubby steppe becomes extremely dispersed. We then sometimes speak of "semi-desert formations" or even "desert", but a word specific to these formations is missing, that of “desert” indicating environmental conditions. Similarly "training very humid climate” cannot replace that of forest or savannah. When steppe constituents become excessively diffuse, it is appropriate to specify by writing “semi-desert steppe”.

Other steppe types differ biologically, their floristic composition varying with the season. Their flora is double, a flora of grasses and a flora of geophytes and dwarf woody plants or strollers whose development takes place in different seasons. Those are truly tropophilic steppes (High plateaus of Kwango and Katanga.) It emerges from all these considerations that a classification of the various types of steppes would be needed.

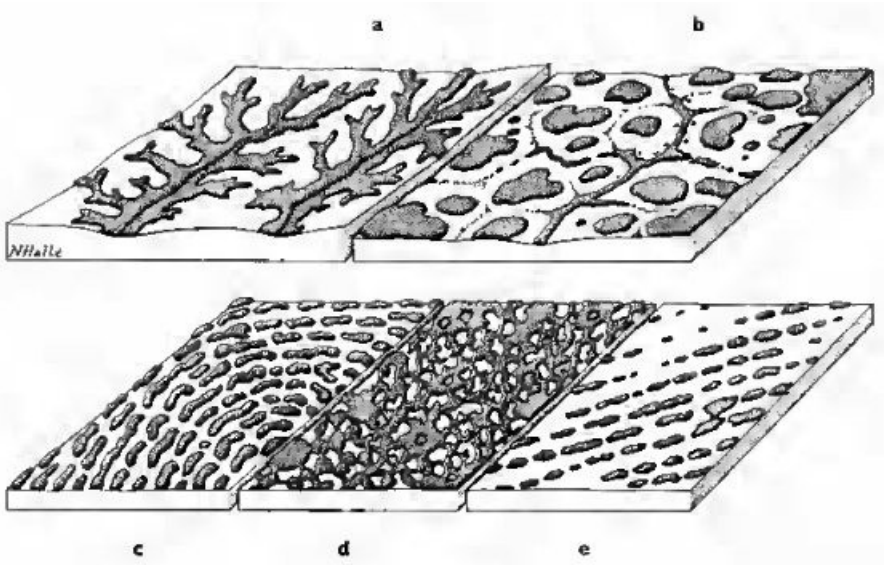
TYPES OF CATENIC AND HYDROMORPHIC DISTRIBUTION OF WOODY FORMATIONS

Some forestry training is distributed in the countries of savannas following bands or spots in relation to the conditions the topography and the nature of the soil, When these reproduce regularly following catenic series of soils the formations in hug the contours and this draws plant landscapes that are sometimes very curious that can be observed seen from the plane. A new terminology was therefore born with the development of air traffic that we seems appropriate to fix like that of the formations themselves.

Forest galleries. — See page 160.

Valley forest. — The dense forest occupies exactly the valleys of rivers dug in sandstone and sand plateaus and garnishes the slopes to the edges of the escarpments. The trays are covered with savannas. It is a sort of extension of the gallery forest to a whole valley.

Ravine woods. — In countries with marked relief, covered with grassy savannahs, woods are found in niches in the relief (circuses, ravines) where they are sheltered from bush fires. This frequent landscape is generally that of a forest in the process of regression and these woods of ravines are in fact the witnesses of the old forest extension.



Pl. 7. — Types de paysages caténiques : *a*, Forêt digitée; *b*, Forêt tachetée; *c*, Fourrés tigrés; *d*, Fourrés ocellés; *e*, Fourrés littoraux.

Finger forest. — Landscape very common in the edge sectors dense forest/savannah. The gallery forests branch out into branches main and secondary compartmentalizing the country into drawn cells by forest lines. This digital forest that extends beyond the area continuous dense forest can sometimes extend very far from the edges in the Savannah. In some plateau countries where erosion is active, the end of the fine ramifications leads to a wooded erosion cirque. Of many names have already been used for this landscape: dendritic forest, reindeer antler, seaweed forest.

Spotted forest. — In the previous landscapes the dense forest occupied all the parts hollowed out by upward erosion. Sometimes on the contrary, the forest forms more or less large patches on the high parts of the relief, inside the cells drawn by the network rivers and thalwegs of tributary

valleys. Cell slopes are lined with a grassy savannah and the thalwegs are marked by thin gallery forests, or simple bands of shrubs.

Mottled forest can be dense forest or open forest, or thickets. Sometimes also the two landscapes coexist: forest (or thicket) mottled and digital forest on white sands (between the Rio Branco and Manaus — Amazonia).

Tiger thickets. — Frequent landscape in the transition region Sudan /Sahel. Thickets are arranged in narrow lines or bands parallel, sometimes more or less concentric, separated by bands of bare ground. The overall appearance is that of a tiger skin. The explanations that have been given of these very curious drawings are not convincing. Tiger thickets are seen on hills but also in absolutely flat terrain.

The "*miombo*" of southern Africa is a mosaic of formations where the genus *Brachyslegia* is particularly well represented, where mingle especially clear forests but also these two extreme terms, the forest dense dry and wooded savannah.

There are also catenated vegetation landscapes, where vegetation types follow one another in regular succession, linked to variations in the nature of the soil, perceptible with topographical variations. Examples of these are given below.

Vegetation formations are usually continuous over large or small areas, but can also be very discontinuous. For example, thickets are sometimes continuous, but sometimes interspersed with numerous patches or strips of bare ground (e.g. tiger thickets, aligned thickets, ocellated thickets, spotted thickets). Again, these are not different formations — there's only one, the thicket — but discontinuous thicket landscapes whose causes can be diverse.

Generally speaking, we need to separate the concept of “plant formation”, a unit of vegetation, from that of “vegetation landscapes” made up of “mosaics”, i.e. assemblages of plots covered with various formations, or landscapes due to the excessive fragmentation of a single formation.

Striped thickets. — Known on the coast of Ghana (region of Accra-Winneba). The thicket strips are aligned and parallel in the coastal grasslands, it is possible that this is an effect of bushfires pushed by a sea wind from the south-west direction constant.

Ocellated thickets. — The thicket is riddled with small white spots circular that correspond to large eroded termite mounds, regularly distributed. No vegetation settles on this land to termiter. Ocellated thickets are seen in the tiger thicket regions of so that it is likely that a relationship exists between the presence of these termite mounds and the formation of the tiger-like appearance.

Speckled thickets. — The thicket is cut into very small patches without special orientation, separated by patches of bare ground.

Coastal rippled thicket. — Strips of thicket parallel to the shorenear by separated by marshy herbaceous strips. They correspond lay at old shore lines.

Coastal thicket. — Shrub strip following the beaches. Behind her, extend grassy savannahs liable to flooding, swamps, or lagoons.

Savannah with copses. — Already described. Corresponds according to us especially to a mode of progression of the forest flora in the savannah grassland on the edges of the forest.

Savanna with shrub/tree termite mounds. — Already described. Seen from the plane, your savannah seems regularly riddled with small spots distributed generally surrounded by a white halo. Matches to flood zones during the flood period, the forest vegetation does not survives only on the mounds of large termite mounds.

Savannah of the esobes. — Grassy savannah of open clearings in the dense Congolese rainforest.

Catenated and Hydromorphic Landscape Types

Vegetation mosaics.	Ocellated thickets.
Forest galleries.	Speckled thickets.
Valley forest.	Coastal rippled thicket.
Ravine woods.	Coastal thicket.
Finger forest.	Bushy savannah.
Mottled Forest (Thicket).	Savanna with shrubby termite mounds trees.
Tiger thickets.	Savannah of the esobes.
Striped thickets.	

CLASSIFICATION PROJECT
TROPICAL PLANT FORMATIONS

I have summarized in a two-part table a draft classification that follows on from the above considerations. In the first part, I have simply written down the main types of formations with a few very general examples. They are in the same order as Yangambi's recommendations, and with the same nomenclature, except for the modifications and additions I have shown to be appropriate. In the second, I have developed the first to some extent, giving type after type of examples with a floristic and geographical nomenclatural basis, chosen or simply gleaned from the tropical world.

It's when you draw up such tables that you come up against a number of difficulties, and realize how great is the lack of documentation in the field of descriptive phytogeography. From personal experience, we can't know them all, and for a worldwide classification we have to draw on the bibliography. It is terribly incomplete. Sometimes even the simplest indications on the structure and rhythm of foliage are missing. As for floristic composition, the information that is sometimes given is usually of no phytosociological significance, consisting of simple species lists. It is then impossible to rationally designate particularly characteristic species, genera or families that could be chosen to designate it.

The project we are presenting, therefore, only has an indicative value. It opens up frames that would have to be filled and proposes names that require will sometimes need to be confirmed by those who have direct knowledge of the training in question. But already. however incomplete and imperfect it may be, it will show the extreme floristic and physiognomic complication of the tropical vegetation, and the need to see more clearly to get along between phytogeographers on definitions, terminology, and classification. Almost all names -- relating to subtypes cited in the table have already been published in the phytogeochart.

I. GENERAL CLASSIFICATION TABLE — TROPICAL PLANT FORMATIONS

A. CLOSED FOREST FORMATIONS

Climatic Types	Principal Geographical & Floristic Subtypes	Edaphico-Climatic Types
Low and Mid-Altitude Forests		
Dense humid evergreen forest.	Guinean-Congolese forest.	Mangrove
	Eastern Malagasy forest.	Swamp forest and swamp palm grove
	Amazonian forest. **Woodlands, Low Forests, Thickets**	Periodically flooded forest
	Indo-Malayan forest with Dipterocarpaceae.	Riparian forest
	Queensland forest with *Proteaceae*, *Myrtaceae* and *Araucaria*.	Forest on white sand
Semi-deciduous dense humid forest.		
Dense dry evergreen forest.	Australian *Eucalyptus* forest	
Semi-deciduous dense dry forest.		
Dense dry deciduous forest.		
High Altitude Forests		
Dense humid evergreen forest.	Brazilian *Araucaria angustifolia* softwood forest.	
Dense dry mountain forest.	Mexican pine-oak forest.	
Bamboo forest.		
Woodlands, Low Forests, Thickets		
From low to mid-altitude		
Mountain		

B. Mixed Forest Formations — Grasses, Herbes

Types Climatiques	Principaux Sous-Types Geographiques et Floristiques	Types Edaphico-Climatiques
Savannahs		
Open Forest	Southern African open forest with leguminous plants Indo-Bismanian open forest with Dipterocarpaceae African Sudan-Zambezi open forest	
Wooded savannah	Brazilian (campos cerrados)	
Shrubby savannah	African savannah orchard	
Wooded savannah	Savannah palm grove	
Savannah with copses		
Thorny savannah		
Grassy savannah		
Steppes		
Steppe with trees and/or shrubs		
Bushy steppe		
Succulent steppe		
Grassy and / or herbaceous steppe		
Prairies/Grasslands/Meadows		
Altimontane meadow		
Aquatique meadow		
Marsh meadow		

II. GEOGRAPHIC SUBTYPES AND FLORISTICS

Low and Medium Altitude Forests

Dense evergreen humid forest:

— Guineo-Congolese forest: Forest with large legumes, Turreanthus forests (Ivory Coast), Lophira forest and Saccoglollis (Cameroon), Forest at Aucoumea and Saccogloltis (Gabon), Forest at Dialium and Desbordesia (Gabon), Forest at Gilberliodendron Dewevrei (Congo), Forest at Brachgslegia Laurenlii (Congo), Scorodophleus Zenkeri Forest (Congo), Open forest and dense Marantaceae undergrowth (Upper Sangha), Palm grove of Elaeis guineensis.

— Eastern Malagasy forest: Coastal forest on sands with Cycas and Afzetia bifuga.

— Subtropical Oleaceae and Podocarpus forest (Knysna-South Africa).

— Amazonian forest with Lecythidaceae, Leguminosae and Humiriaceae: Forest at Vouacapoua, Forest at Vochysiaceae; Guyanese forest in Eschweitera and Licania; in Eschweilera and Dicymbus; to Goupia, Swartzia and Aspidosperma; in Ocolea Bodiaei.

— Atlantic forest (slope) of Central America: Forest with Dialium and Terminalia amazonica (Mexico), Forest at Brosimum alicaslrum (Mexico), Forest at Penlaclelhra macroloba (Costa Rica).

— Pacific forest (slope) of Central America: Palm grove in Orbignya guacuyute (Mexico).

— Indo-Malaysian forest with Dipterocarpaceae: Forest with Diptero- carpaeae, Lauraceae and Mesua ferrea (India, Ceylon), Dipterocarp and Magnoliaceae Forest (Assam), Dipterocarp Forest (Malaysia), Eusideroxylon Forest zwageri (Borneo).

— Queensland forest with Proteaceae, Myrtaceae and Araucaria (Australia).

— New Caledonian forest: at Agathis, Monirouziera and Arau¬ caria balansae, Sprrrnolepis ga mail¬ open high forest lera and sclerophyllous undergrowth, Forest with Agalhis avala and Casuariria Deplancheana.

Dense moist semi-deciduous forest:

— Guineo-Congolese forest: Forest at Malvales and Ulmalcs; Forest to Ulmaceae, Sterculiaceae, Sapotaceae and Meliaceae (Ubangui-Sangha); Forest at Cynomelra Alexandrii (Congo).

— Western Llanos Forest (Venezuela): Forest in Bombacopsis, Piralinera and Schellea.

— Forest of the Rio Branco at Cordia and Centrolobium.

— Yucatec forest at Nispevo achras on limestone (Mexico).

— Sino-Indo-Burman forest in Lauraceae and Meliaceae (Yunnan).

Dense dry evergreen forests:

— Australian Forest (Eucalyptus.

Dense dry semi-deciduous forest:

— Western Malagasy forest.

— Tucumano-Bolivian Leguminosae Forest (p).

— Ceylonese forest with Manilkara hexandra, Chloroxylon and Drycles sepiaria.

Dense dry deciduous forest:

— Malagasy forest of the south-west with arborescent Euphorbias and Adansonia.
— Kalaharian forest with Baikiaea plurijuga.
— Central Llanos Forest (Venezuela).
— Forest at Bursera (Mexico), at Juliana adslringens (Mexico), Low forest of the Pacific coast (Mexico).
— Forest of Chaco (each) with Leguminosae and Schinopsis.
— Indian forest with Teclona (teak) and Shorea robusla.
— Indian forest with Shorea robusla, Anogeissus, Hardwickia and Terminalia.

Edaphico-climatic types.

— Mangrove: at Bhizophora, at Avicennia, at Bruguiera, at Cono-carpus, etc.
— Coastal forest in Barringlonia (Malaysia).
— Swamp forest and swamp palm grove:
— Africa: Pandanus, Baphia spp., Syzygium, Alilragyne, Alchornea cordifolia, Symphonia globulifera, etc...
— America: Virola surinamensis, H tira crepilans, Plerocarpus draco, Symphonia globulifera, Drepanocarpus lunalus, in Mora excelsa (Guinea), in Carapa guianensis (Guyana), etc.
— Igapo Forest (Brazil).
— Malaysia: at Melaleuca leucadendron, swamp palm grove in Melroxylon (Moluccas, New Guinea), Peat forest.

Periodically flooded forest:

— Africa: in Guibourlia Demeusii and Ubanguia, in Xylopia elhiopica, in Cynomelra.
— America: high varzea of the lower Rio Negro with Leguminosae and Annonaceae, varzea with Eulerpe oleracea (Amazonia), Palm grove at Scheelea Liebmanii (Vera Cruz), in Royslonea and Pachira aquaiica (Vera Cruz), in Bravaisia inlergrerrina (Mexico), at Symphonia, Tabcbuia and Eulerpe (pegasus of Guyana), Manicaria saccifera palm grove (Guyana), at Iryanlhera-Tabebuia (Guyana), to Clusia fockeana (Guyana), in Maurilia (lexuosa (Guyana).
— Malaysia: in Vatica Wallichii, in Shorea albida (Borneo).
— Cambodia: with Homalium breoidens and Hydnocarpus anthelminthica.

Riparian forest (and forest fringe):

—Africa: in Oxysligma, in Vapaca Heudetolü, in Irvingia, to Manilkara, to W ildemaniodoxa, to Zeyherella longepedicellala, at Phoenix reclinala and Sesbania sesban (Lake Edward).
— America: Mora excelsa (Guyana), Eperua leucanlha, to Carapa guianensis, to Maurilia minor (Venezuela), to Cecropia spp., to Maurilia (lexuosa.
— Malaysia: to Dipkrocarpus oblongifolius.

Forest on white sand:

— America: in Eperua falcala and Dimorphandra (Wallaba forest, Guyana).

Low forest in Humiria (Brazilian Guiana).

— Malaysia: at Dacrydium and Casuarina (Heath forest).

High Altitude Forests.

Dense evergreen (and semi-deciduous) moist forest of Mountain :

— Eastern afromontane forest: Podocarpus forest, Crolon megalocarpa forest (Kenya), Aphloia forest and Maesa (Nyasaland), Forest with Hagenta abyssinica and Umbelliferae (Congo), Tree heather forest (Philippta and Erica), Forest at Macaranga neomitdbraedia (Congo).

— Andean forest: Podocarpus forest, Tucumanian forest in Myrtaceae.

Brazilian forest with Araucaria angustifolia.

— Mexican semi-deciduous forest at Liquidambar, Forest of Quercus spp. (Mexico, Costa Rica).

— Montane Malay Forest: Mossy Forest in Eugenia and Vaccinium, Agathis Forest (Celebes, New Guinea, Moluccas), Lilhocarpus Havilandii Forest (Borneo).

— Lauraceae forest of the sholas (India, Ceylon).

— Hawaiian forest at Mdrosideros polymorpba.

— New Caledonian forest with Araucaria Humboldlensis.

Dense dry mountain forest:

— Eastern Afromontane softwood forest: Juni-crus procera and Olea chrysophylla, Podocarpus Forest and Ocolea, Forest at Widdringlonia Whylei (Nyasaland), Forest with Newlonia Buchananii.

— Mexican pine-oak forest.

— Tucumano-Bolivian Leguminosae Forest (p).

— Himalayan Forest with Pinus Boxburghii.

Bamboo forest:

— Afromontane bamboo forest in Arundinavia alpina, Bambu-Himalayan meadow with Arundinaria racemosa.

Thickets, Low Forests

Low and medium altitude:

— Africa: Deciduous thickets with Combrelum and Papiliones (N. Rhodesia), Commiphora (N. Rhodesia) thickets, coastal Chrysobalanus thickets, subtropical sclero-Cape phylls, Acacia delinens thickets (Angola), Thickets Kalaharians with Cryplosepalum, Thickets with Slrychnos ligusIroides (Angola), Thickets at Combrctam inicranlbnm (Sudan).

— Madagascar: Woods thickened with Didiéracèes and Euphorbias.

— America: Thickets on white sand from the upper Rio Negro to Aldina and Bromeliads, Wood thickets on white sand at Aldina discofor and Cantpsoneura debilis from the rio Uaupes, Periodically flooded thickets of Haemaloxylon campe- chianum (Yucatan), Deciduous woods

with Cacti from the Brazilian and Venezuelan catinga, Deciduous thickets to Cacti, Legumes, Bignoniaceae from the Caribbean coasts (espinares), Thickets with Proposis juliflora and Cacti (Haiti), Thickets on white sands with Clusia fockeana, in Humiria (Guyana).

— Asia: Wood-thickets with Albizzia amara and Chloroxylon (India), Low forests with Anogeissus pendula (India).

— Australia: Thickets of Acacia aneura (mulga), Eucalyptus.

— New Caledonia: thickets on serpentine, thickets with Acacia spirorbis, Hibberlia and Slenocarpus thickets.

From high altitude:

— East Africa; Heather thickets, Acanthaceae thickets, Sclerophyllous thickets of Newlonia Buchanartii Thickets at Cornus and Agauria on lavas, low forest at Nèo-boulonnia macrocalyx and Mimulopsis arborescens (Congo), Forest low sclerophyll with Myriea salicijolia and Bersama ugandensis (Congo), Grcwia and Carissa thickets, Lady's Mantle, Groundsel and Giant Lobelias, Thickets with Giant Helichrysum and Lobelias, Ragwort thickets (Ruwenzori).

— Madagascar: Ericaceae and Compositae thickets, Uapaca Bojeri (tapia) and ericaceous, thicket woods at Chlénacees.

— America: Andean thickets of Polycarp and Alnus.

— Borneo: Thickets of Rhododendrons.

— New Caledonia: Sclerophyll thickets with Myrtaceae and Cunoniaceae umbelliformes, Thickets with Dacrydium araucarioids.

Landes.

— New Caledonia: Pleridium aquilinum fern, heathland with Eriaxis rigida and geophytes.

Savannahs.

Clear Forest:

— Southern African woodland à Legumes: Forest at *Brachyslegia*, Jubernardia (miombo), Forest in Alarquesia, Colophospermum mopane (mopani) forest; Forest at Baikiaea plurijuga on sand; Forest in Burkea, Guibourlia, Baikiaea; Forest at Erylhrophleum.

— Sudanian African woodland: Forest with Isobtrlinia and Uapaca, Anogeissus Forest, Boswellia Forest.

— Montane sclerophyllous woodland with Alyrica salicijolia (Congo).

— Mexican montane clear forest of pines, Juniperus.

— Mexican open forest of oaks.

— Indo-Burmese Dipterocarp woodland: at Diplerocarpus tuberculalus; to Diplerocarpus oblusifolius; in Pentaeme suavis and Shorea oblusa; to Diplerocarpus and Terminalia lomenlosa.

— Australian woodland at Callitris.

— Montane woodland with Casuarina junghuhniana (Java), Montane pine forest (Philippines, Sumatra).

Wooded savannah and shrubby savannah:

— Sudano-Zambézian wooded savannah: at Lophira, at Terminalia, Cornbrelum, Mo noie s, Burkea, Parinari, Bombax coslalum, with Hymenocardia acida, with Cussonia angolensis, etc.

— Shrubby savannah of the llanos in Curalella (Venezuela); savannah shrub to Brysonima crassifolia and Curalella.

— Brazilian wooded savannah (campos cerrados).

— Melaleuca leucadendron savannah (New Caledonia).

— African orchard savannah: Bulyrospermum Parkii (Sudan); in Faidherbia albida (Sudan); in Parkia (Sudan).

Wooded savannah and palm savannah:

— Africa: at Borassus; to Daniellia; at Acacia.

— Madagascar: at Medemia; at Hyphaene shalan.

— America ; to Copernicia australis; in Maurilia, in Copernicia teclorum (Venezuela); in Copernicia cerifera-, in Sabal Mexicana (Vera Cruz).

Savannah with copses:

— Llanos of Venezuela.

Thorny savannah:

— to *Prosopis spicigera* (India); in Acacia Sieberiana (Congo); to *Acacia campylacantha* (Africa).

Grassy savannah:

— Africa: at Imperala; at Pennisetum purpureum; in Themeda triandra (South Africa); to Hyparrhchnia; in Andropogon; etc...

— America: in Trachypogon (Venezuela), etc...

Steppes.

Tree and/or shrub steppe:

— West Africa: at Acacia senegal; at Commiphora africana; at Acacia Baddiana

— Southern Africa: at Acacia Giraffae; at Acacia Karroo; in Euphorbias.

— South-West Africa: at Welwilschia.

— America: with Larrea divaricala and Cacti (Mexico, Monte Argentine); Palm grove in Brahea dulcis (Mexico); steppe halophile in Suaeda and A triplex (Mexico).

— Asia: with Albizzia amara, Acacia, Anogeissus pendula and Prosopis spicigera (India).

Bush Steppe:

— Australia: at Triodia (spinifex).

Succulent Steppe:

— Africa: with Pachypodium namaguanum (SW Africa), Karoo.

— America: in Cacti; in Neobux-baumia lelelzo (Mexico); to Bromeliads; in Agaves; in Nolina; at Dasylirions; at Fouquiera' to Lemaireocareus Thurberi; to Yucca filifera] in Yucca decipiens; to Yucca periculosa.

Herbaceous and/or grass steppe;

— Africa: at Slipa, at *Chrysopogon Aucheri*; at *Trachypogon Thollonii* (Congo); to *Loudelia Demeusii* (Congo); in *Loudelia simplex* (Congo); to *Loudelia arundinacea* (Congo).
— America: Andes: puna. Mexico: *Bouleloua gracilis*, *Hilaria mulica*.

Meadows.

Altimontane meadow:

— America: Andes: paramo, puna.
— Africa: to Fesluca abyssinica; with Agroslis isopholis and Lobelia mildbraedii; Forest-Prairie: in giant Lobelia and Senecio.
— New Caledonia: in *Xeronema moorei* and *Greslania circinnata*.

Water meadow:

— Africa: to *Echinochloa pyramidalis*.
— America: at *Typha*.

Beach grass formations with Ipomoea pes-caprae.

Swamp Meadow:

— Africa: with Cyperus papyrus and Cyclosorus gongylodes, with Carex.
— America: with *Thalia geniculala* (Mexico), *Heliconia*, *Montrichardia*, *Cyperus giganleus*, *Eichornea*.

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